



Bioceramics in Endodontics

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Introduction

Bioceramics are biocompatible ceramic materials, inert to the human body, which are used in a variety of medical procedures (1). These materials are durable ceramic or metal oxides with the requisite biocompatibility to either function as human tissues or to resorb and encourage the regeneration of natural tissues (2). Endodontic applications include surgical root end filling material, root repair material, root canal sealer and pulp capping material. The purpose of this clinical update is to explore the appropriate clinical applications of bioceramics as they pertain to the practice of endodontics.

Mineral Trioxide Aggregate

A well established bioceramic endodontic material is Mineral Trioxide Aggregate (MTA), which has been marketed as ProRoot® MTA (Dentsply Tulsa Dental, Tulsa, OK) since its approval by the FDA in 1998. MTA is a bioaggregate of calcium silicates, similar to Portland cement, with the addition of bismuth oxide for radiopacity and calcium sulfate dehydrate (gypsum) for improved handling properties (3,4). The clinical efficacy of MTA is well established, however, its drawbacks include difficult handling characteristics, long setting time (5), low strength upon initial set (6), and the potential for tooth discoloration associated with the leaching of trace metals from the material (7,8). Newer bioceramic materials have been introduced with the intention of duplicating the clinical success of MTA while improving upon some of its non-ideal properties.

Bioceramic Root Repair Materials

An example of a newer root repair material is EndoSequence® (ESRRM; Brasseler USA, Savannah, GA). This material is commercially available as either a putty or a syringable paste. Research suggests this material is equal in biocompatibility to MTA (9) with minimal cytotoxicity (10). The putty and syringable paste demonstrated similar antibacterial efficacy when compared to white MTA against ten clinical strains of *E. faecalis* (11). It has also demonstrated an equal sealing ability when compared to white MTA against *E. faecalis* (12), however, the pH is significantly lower than MTA (13). Despite marketing strategies that state ESRRM sets faster and possesses finer handling properties when compared to MTA, a recent study revealed that MTA consistently set faster than ESRRM in the presence of blood (14).

BioAggregate® (Innovative BioCeramix Inc, Canada) is another newer bioceramic root repair material that is also

available as DiaRoot Root Canal Repair Filling Material (DiaDent, Canada) (15). BioAggregate® has demonstrated *in vitro* sealing abilities comparable to MTA (16), strong antibacterial properties against *E. faecalis* (17) and antifungal properties against *C. albicans* (18); furthermore, it has demonstrated biocompatibility similar to that of MTA (19). BioDentine® (Septodont, Saint Maur des Fosses, France) is a similar product, with the addition of calcium chloride as a setting accelerant, that is packaged in pre-mixed capsules and designed to set between ten and twelve minutes (20). This material has demonstrated superior dentin calcium uptake when compared to MTA (21).

Bioceramic Root Canal Sealers

ProRoot Endo Sealer™ (Dentsply Tulsa Dental, Tulsa, OK) is a tri-calcium silicate based product designed to be used as a sealer while maintaining properties similar to MTA. Studies suggest that ProRoot Endo Sealer, which demonstrates sealing ability comparable to epoxy resin sealers, has bioactive apatite deposition (22), improved setting time over MTA, and similar dimensional stability when compared to MTA (23). I Root SP® (Verio Dental, Canada) is a calcium silicate based sealer designed for use without mixing. The setting reaction is activated by moisture in the dentinal tubules (24). This product demonstrated similar push-out bond strength to AH Plus® epoxy resin sealer (Dentsply Maillefer, Switzerland) (25). EndoSequence® BC Sealer™ (Brasseler USA, Savannah, GA) is a calcium silicate sealer with high pH (greater than 12) that is designed to initiate set by contact with tubule moisture (26). This material demonstrated significantly lower cytotoxicity than AH Plus® or a ZOE sealer, Tubli-Seal EWT™ (Sybron Endo, Orange, CA) (27). These *in vitro* results appear to be favorable for bioceramic sealers. However, a potential limitation of these materials is that, if retreatment is indicated, they cannot be reliably removed from canals by either rotary instruments or conventional solvents (28).

Bioceramics and Vital Pulp Therapy

Calcium hydroxide has long been the standard material used for vital pulp therapy. However, MTA has been shown to provide superior results over calcium hydroxide in terms of predictability and thickness of dentin bridging to maintain pulp vitality (29). BioDentine® is also a bioactive dentin substitute restorative material suitable for pulp capping (30). It has been clinically shown, in vital pulp therapy, to produce dentin bridging similar to that of MTA with an absence of inflammatory pulp response (31). Considering the favorable setting time and restorative properties of BioDentine®, this material shows great potential as a pulp capping agent and dentin substitute restorative material (32). Bioceramics hold promise in this area,

however MTA has a long and successful history. MTA is clearly superior to calcium hydroxide due to its more uniform reparative dentin layer and less inflammatory response. A high level of evidence demonstrates that MTA should replace calcium hydroxide as the material of choice in pulp capping.

Conclusion

Bioceramics offer a variety of new treatment options with the potential for improving treatment prognosis in many endodontic procedures. These materials appear to demonstrate biocompatibility and antimicrobial properties similar to that of MTA. Bioceramics show promise and may surpass traditionally used materials such as $\text{Ca}(\text{OH})_2$, Glass ionomer, composite and amalgam due to their seemingly superior biocompatibility and improved handling characteristics. With the majority of research on these new bioceramic products being benchtop studies, clinical efficacy can not be determined. With further in vivo clinical research, these bioceramic products have the potential to become the preferred materials in endodontics for sealers, root repair materials, and pulp capping materials.

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